

Marine Noise and the Offshore Oil & Gas Industry

Activities and Sources

J.P. Ray
API/OOC/Industry Operators

The Offshore Industry

- Geographically diverse
 - Arctic to tropics
 - Coastal to abyssal plains of the deep ocean
- Wide range of activities
 - Exploration; development; production
 - Transportation
- Wide range of noise sources

Operations in Marine Mammal Areas

- Baleen whales
 - Bowheads in Beaufort Sea
 - Gray whales – California; Bering Sea
- Toothed Whales
 - Sperm whales – Gulf of Mexico
 - Beluga – Beaufort Sea & Cook Inlet
- Delphinids
 - Most areas

Activities

- **Construction**

- **Platforms**

- Installation barges; platform placement;
 - anchoring; pile driving; conductor driving

- **Subsea infrastructure**

- Wellheads
 - Flow lines
 - Pipeline trenching

- **Pipelines**

- Lay barge operations
 - Trenching

- **Island & causeway construction**

- **Explosive removal (EROS)**

Sources

- Ships

- All sizes
 - Zodiacs
 - Crew boats (60-120')
 - Work boats (90-250')
 - FPSO's
- 5-30 knts
- Thrusters
- Anchoring

- Aircraft

- Helicopters
 - Variety of sizes
- Fixed wings

- Platforms

- Anchoring
- Drilling
 - Pipe running
 - Drilling machinery
 - Pumps, etc.
- Engines
 - Diesel
 - Turbines
- Production

Platforms/Drilling Rigs



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Platforms/Drilling Rigs



Ships



Ships



Ships



Ships



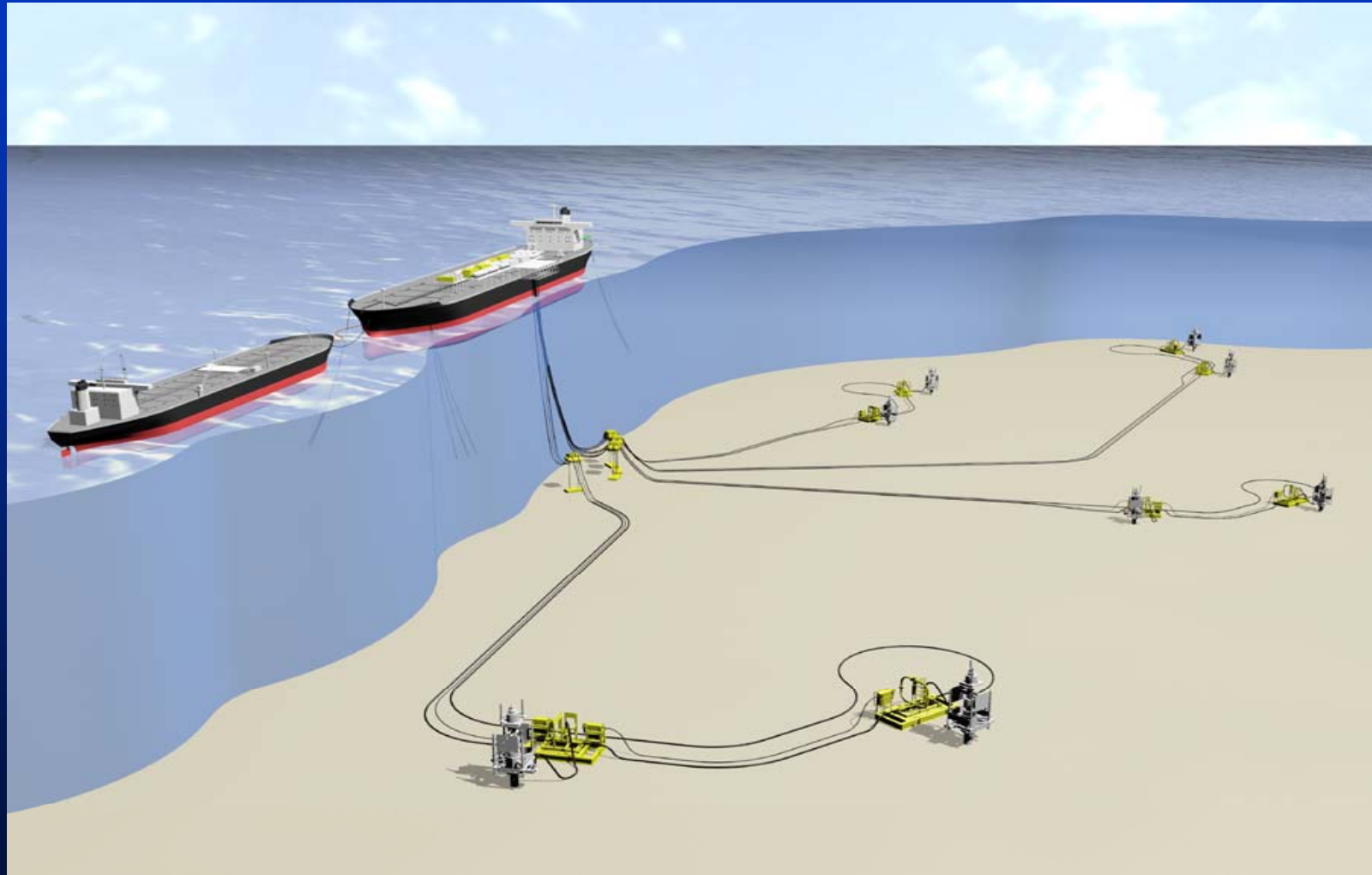
Ships



Ships



SUBSEA TREES & FLOWLINES TO FPSO



Aircraft



Aircraft



Aircraft



Aircraft



Aircraft



Sound Characteristics

- **Aircraft**

- **Helicopters** – general low freq (< 50 Hz); source ~ 150 dB. Many variables.
- **Fixed wing** – most < 500 Hz; \sim dB 150-160

- **Boats**

- **Medium – large: tones dominate to 50 Hz**
 - **Broadband to ~ 100 kHz, peak 50-150 Hz**

Sound Characteristics

- **Boats**

- Tankers & freighters (slow diesels < 250 rpm)
- Supertankers – peak in 100 Hz range; ~ 170-190 dB
- Thrusters – higher freq., sometimes add 10 dB
- Small boats – higher frequency

Sound Characteristics

- **Platforms (bottom founded; drilling)**
 - Not very noisy (limited studies)
 - Strongest tones near 5 Hz (119-127 dB)
- **Drilling vessels (semi's & ships)**
 - Ships noisier (more hull area; thrusters)
 - Semi's – Bering Sea. Broadband levels to ambient by 1 km. Weak tones to 18 km.
- **Production platforms**
 - Gales (1982) – 11 platforms. Strongest tones from 4.5-38 Hz.
 - 2 platforms had peaks between 50-200 Hz & 100 – 500 Hz

Significant Policy Issues

- Issuance of reasonable, scientifically based operating permits
 - Standoff distances
 - Operating restrictions
- Definitions & interpretation of “take” provisions
 - What really constitutes “harm” to a species
- Biological Opinions
- Improvement in scope & funding for government marine mammal & acoustics research

Scientific Issues

- **Distribution of species**
- **Basic biology of species of interest**
- **Scientific research permits**
- **Characterization of sound sources**
- **Calibration of acoustical equipment**
- **Improvement of attenuation models**
- **Understanding relationship between sound and animal responses**
 - **When is sound truly detrimental???**

An Ongoing Relationship



Christopher Richter for the Minerals Management Service

Marine Seismic Surveys Sources of Acoustic Emissions



Marine Mammal Commission Advisory Committee Meeting – February 3, 2004
Philip M. Fontana
Geophysical Manager - Marine Data Acquisition
Veritas DGC, Inc.

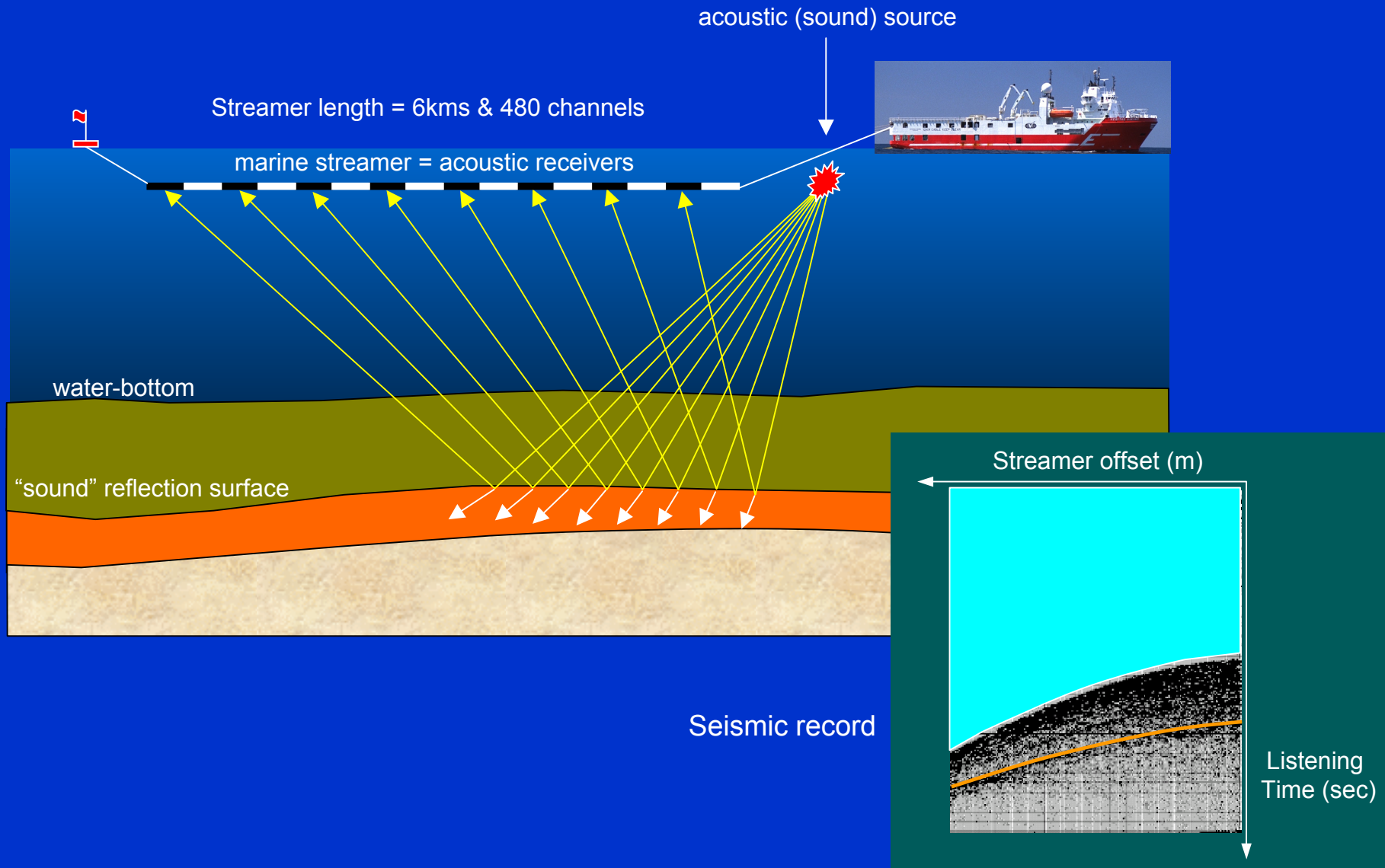
Seismic Survey Vessels

Purpose-built seismic vessels in operation today have been designed to minimize ship-radiated and cavitation-induced noise.

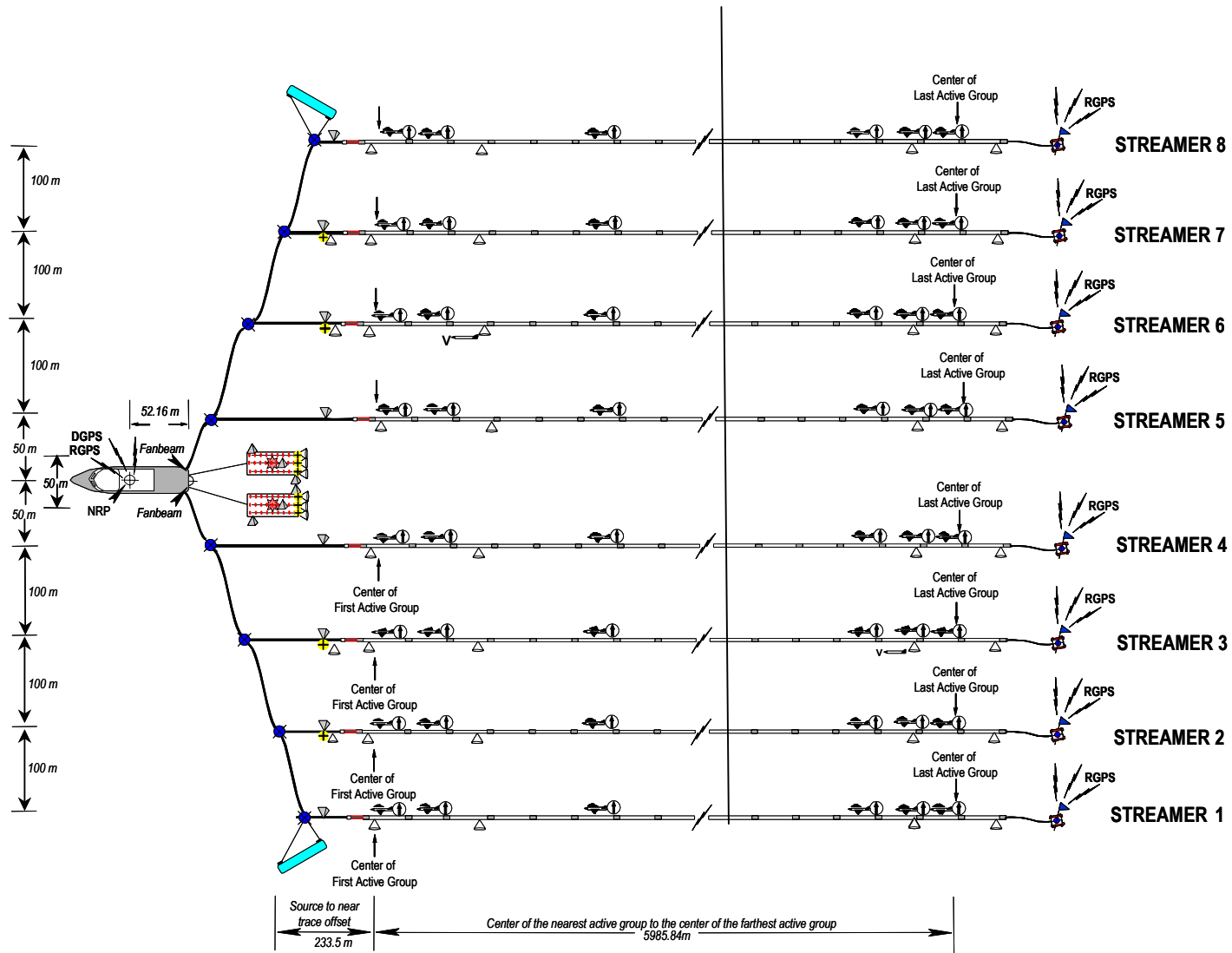
It's vital to our data quality that we operate quiet ships !



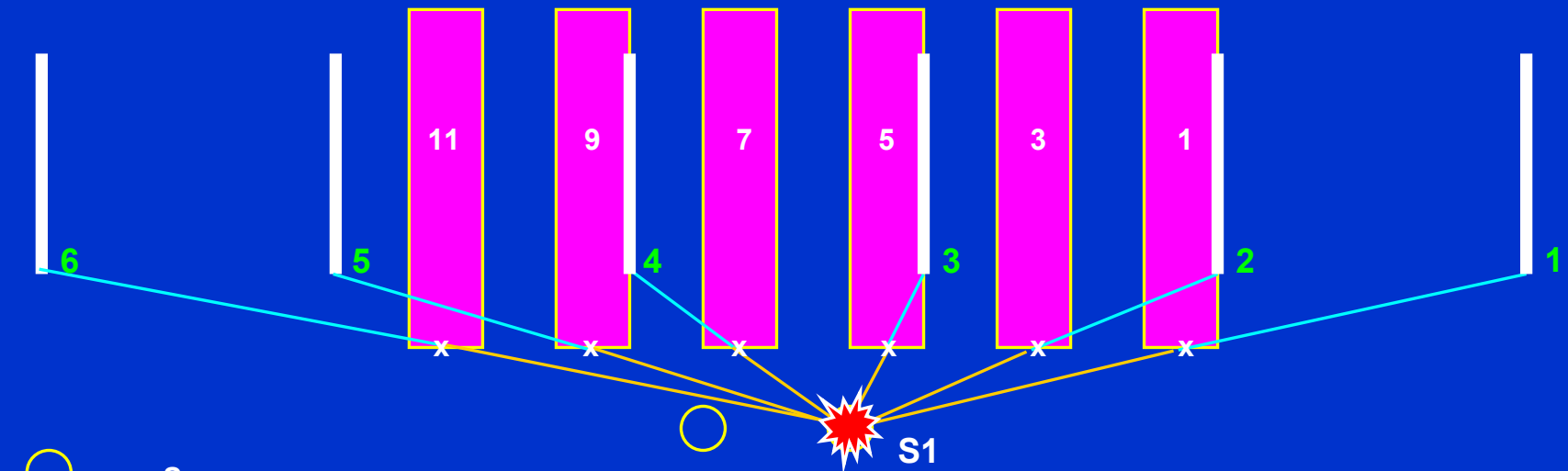
Marine Seismic 'Spread' Elements



3D Seismic Layout



3D Layout



Source



Streamers



Nominal down-going energy



Source-near offset midpoint



Nominal up-coming energy

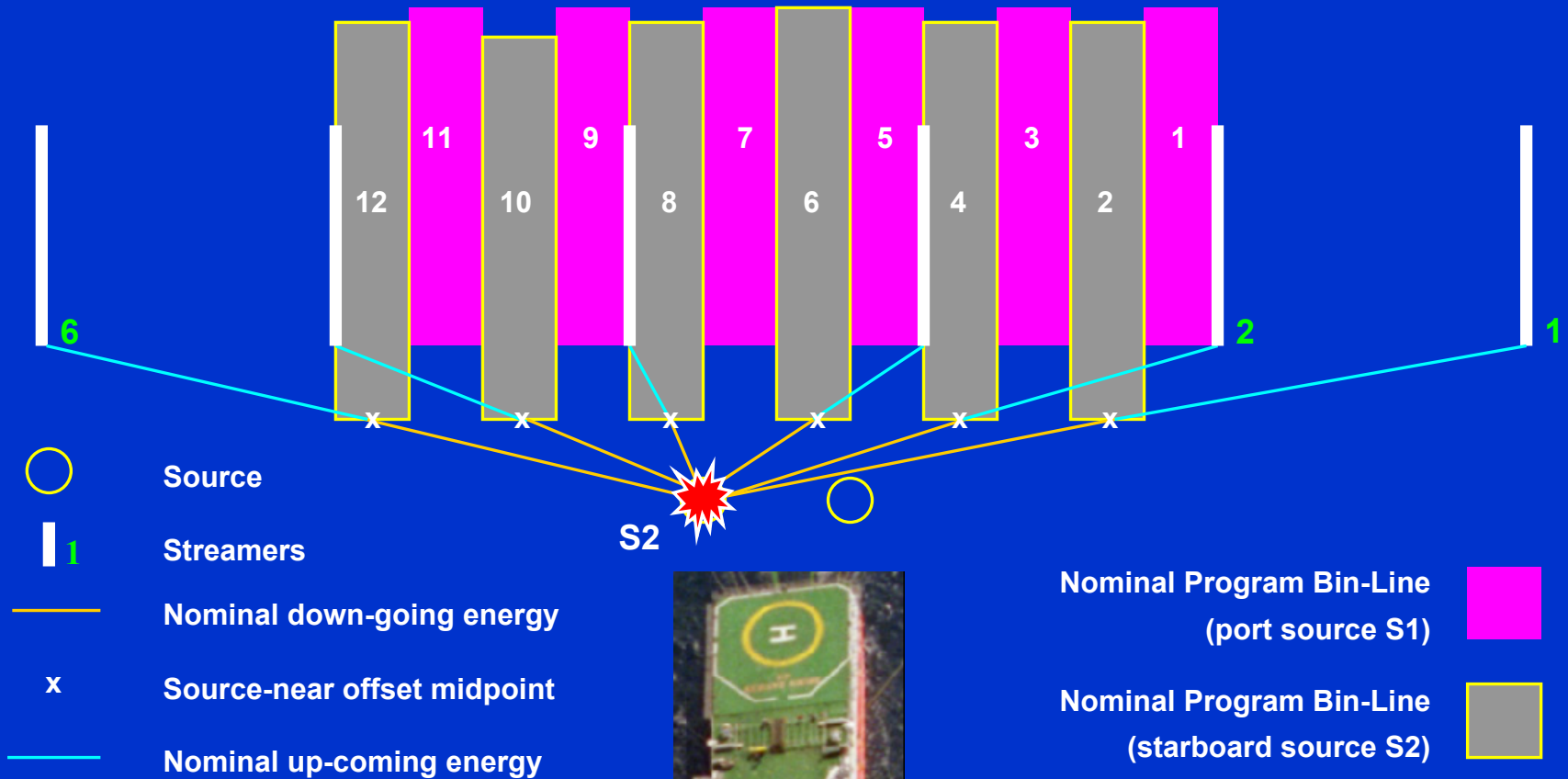


Nominal Program Bin-Line
(port source S1)



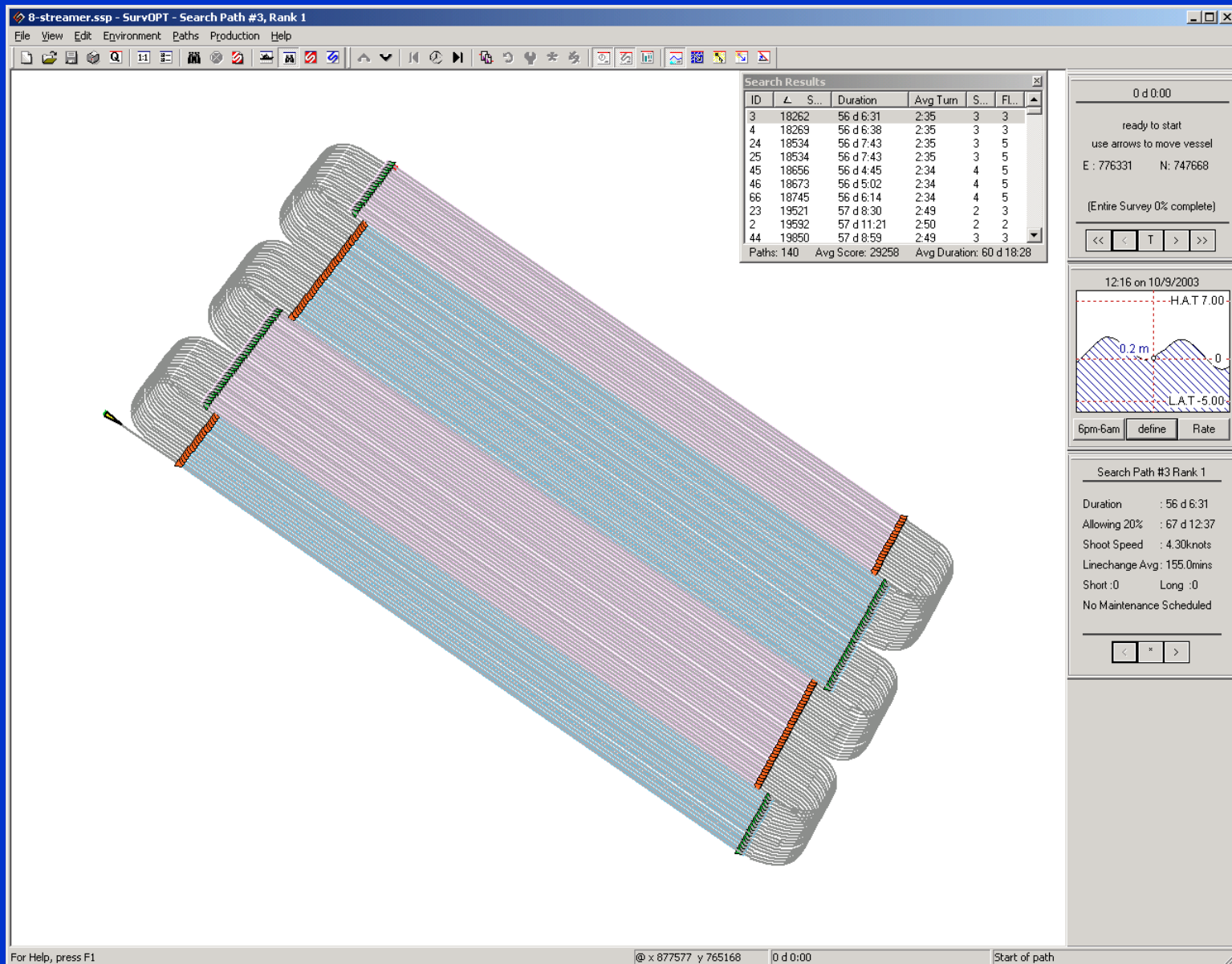
Dual Source + 6 Streamers

3D Layout



Dual Source + 6 Streamers

Survey Sail-line Script



Overview of Seismic Survey Acoustic Emissions

Survey Vessel Radiated Noise

1 - 150 Hz

<170 dB

Continuous

Seismic Airgun Sources

5- 400 Hz

<235 dB

Impulsive

Acoustic Positioning Devices

50 - 100 KHz

<190 dB

Impulsive

Echo Sounders

12 KHz

<210 dB

Impulsive

200 KHz

<215 dB

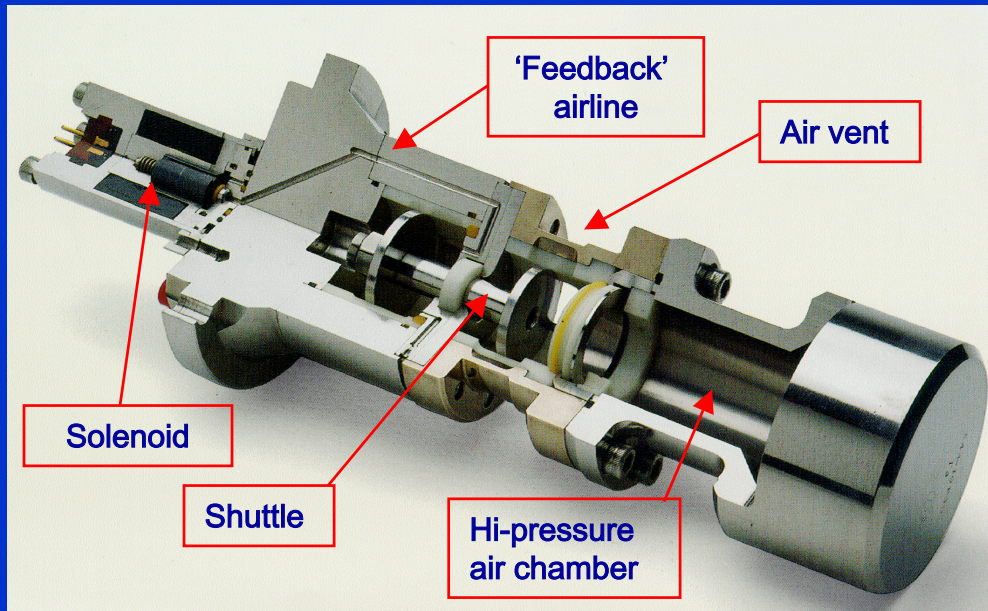
Acoustic Current Profilers

> 1 MHz

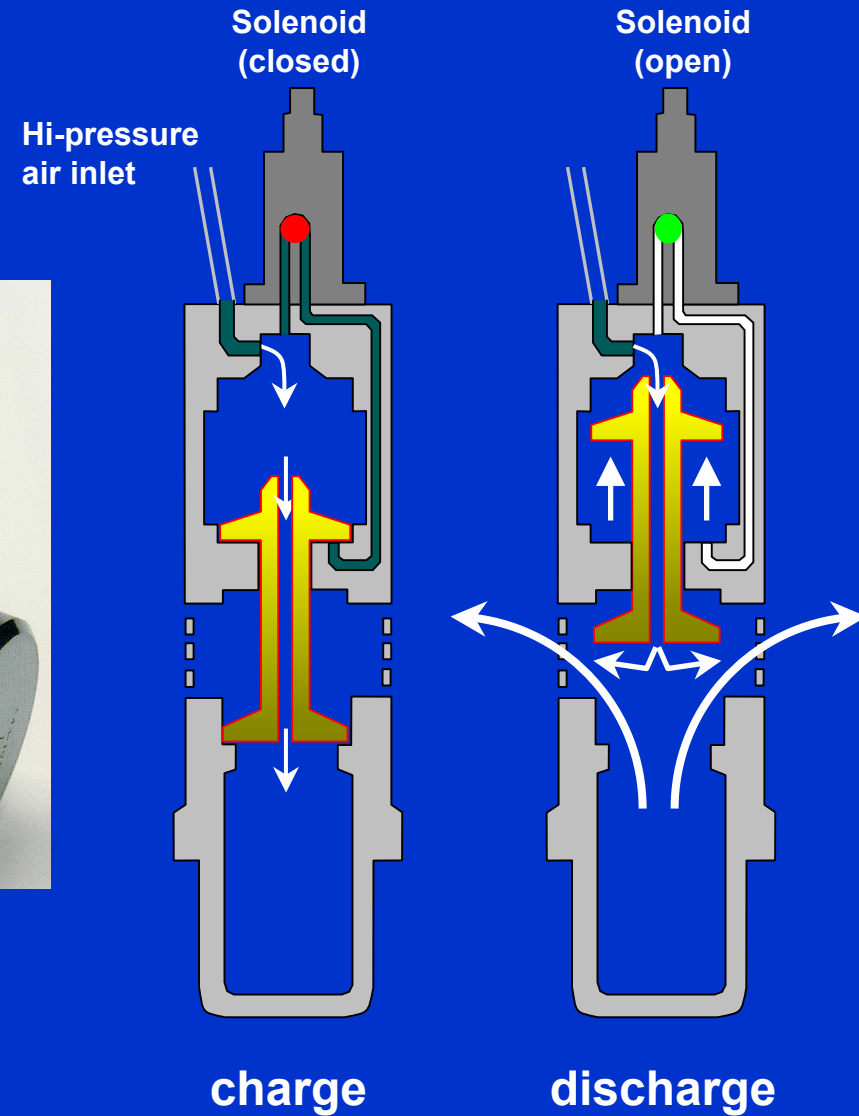
?

Impulsive

Airguns



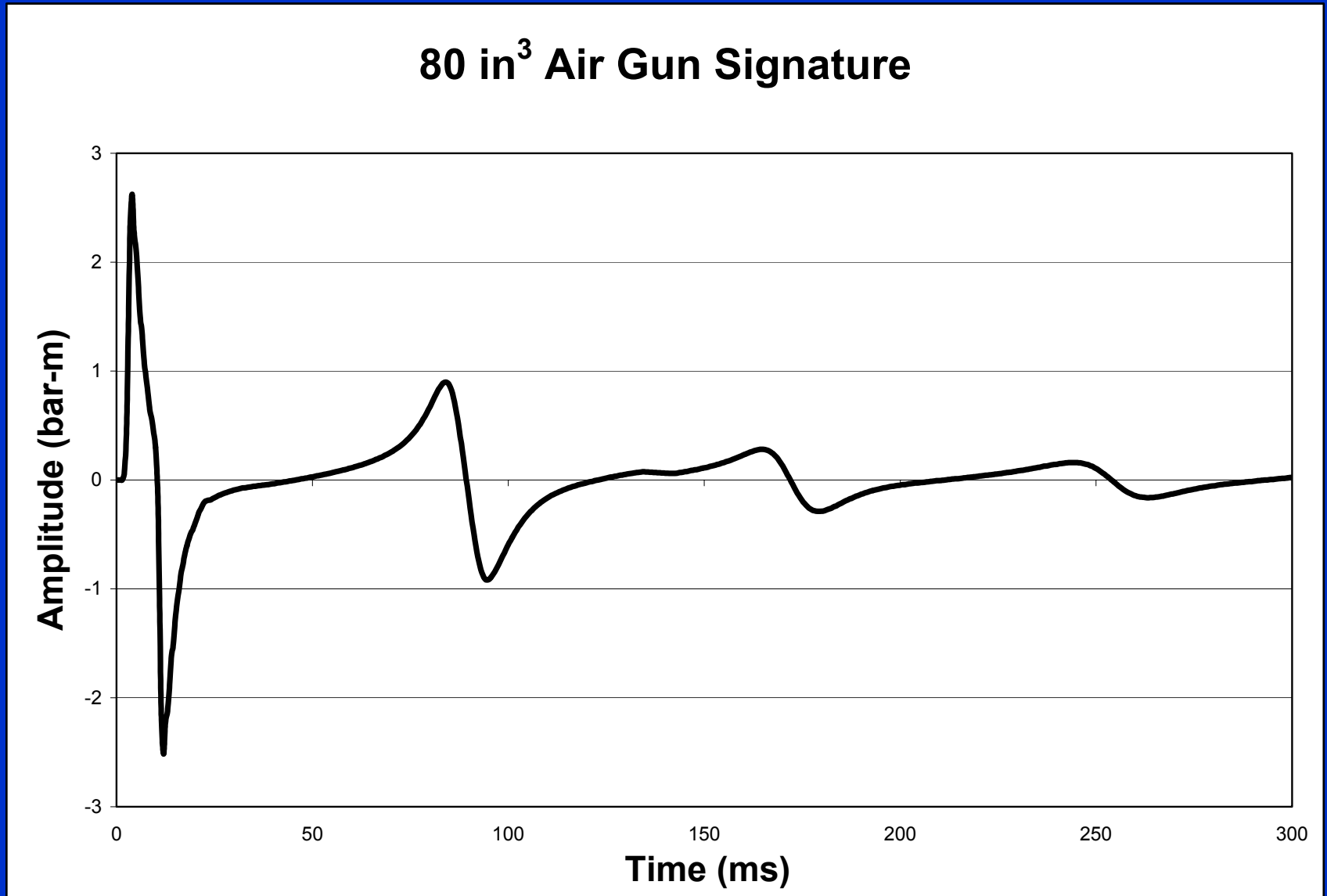
'Exploded' view & operation of a Bolt 'long life' marine airgun



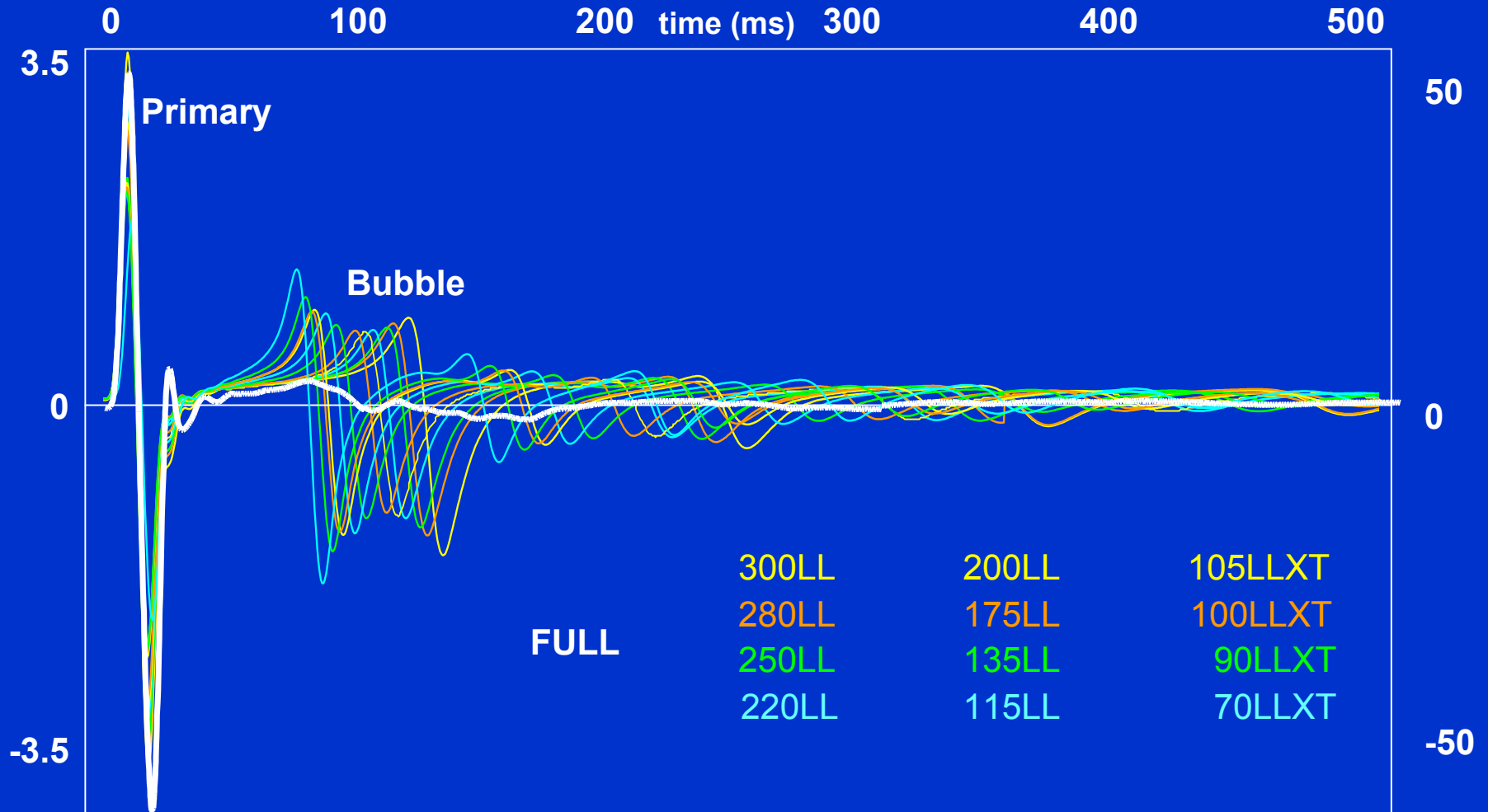
Airguns



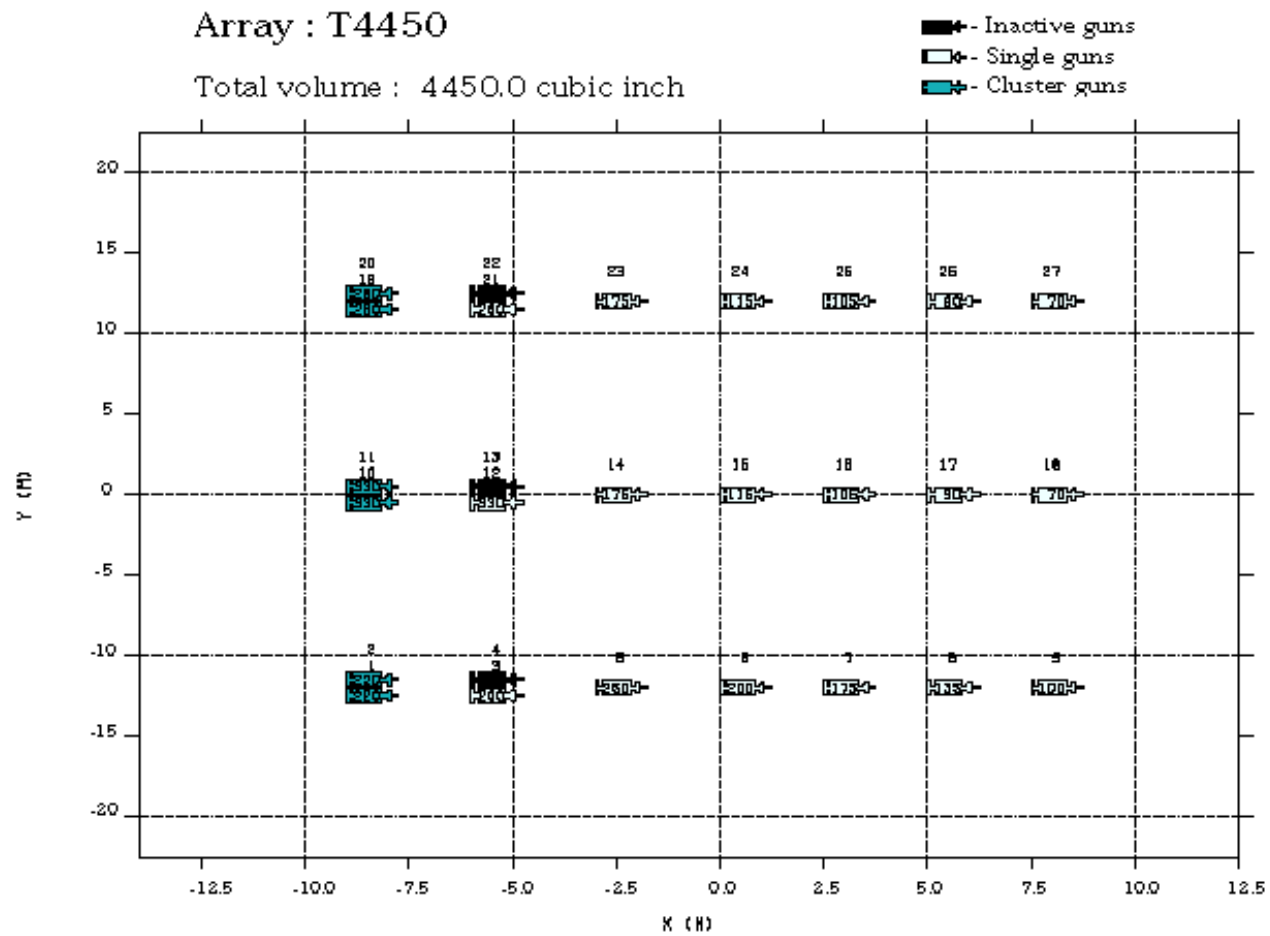
Single Airgun Pressure Signature



Airgun Arrays

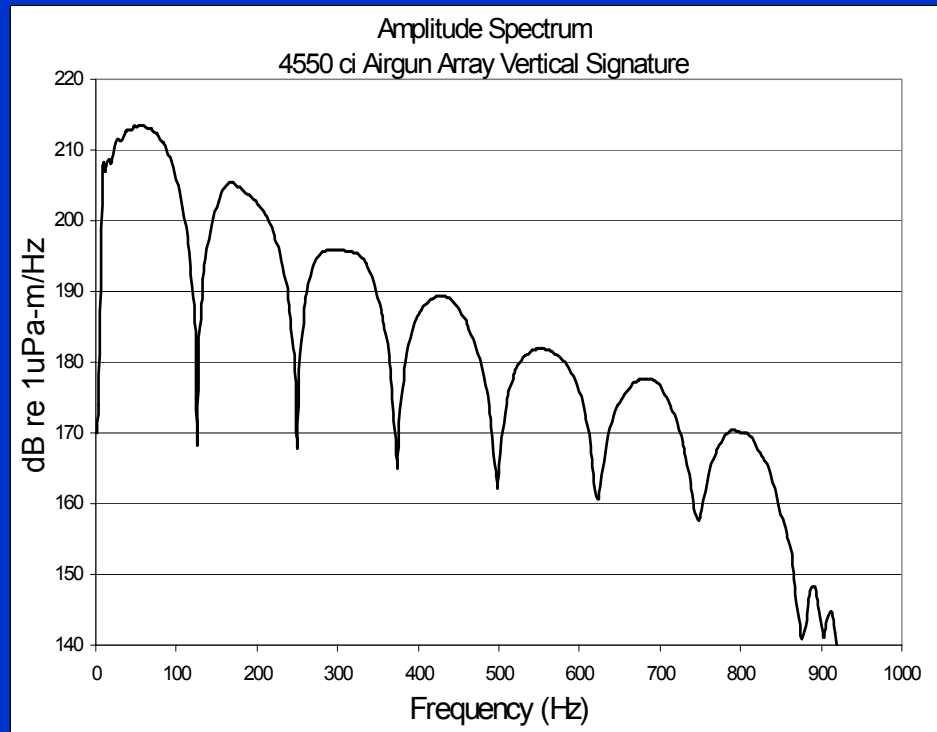
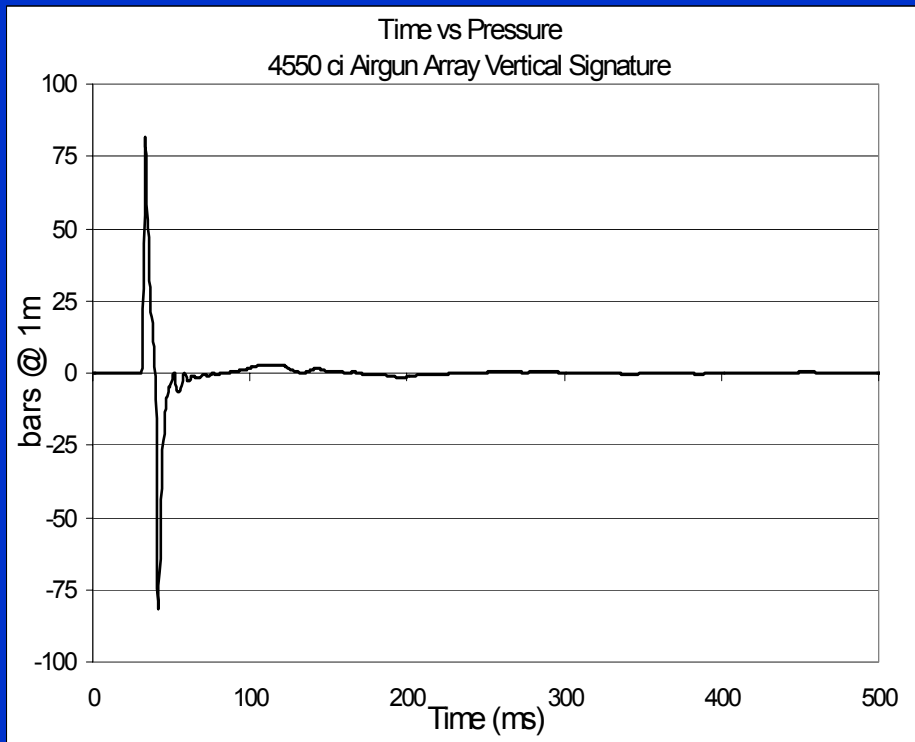


Airgun Arrays



Airgun Array Signatures

Typically the output of an airgun array is referenced to an imaginary point 1m below the center of a theoretical point source.



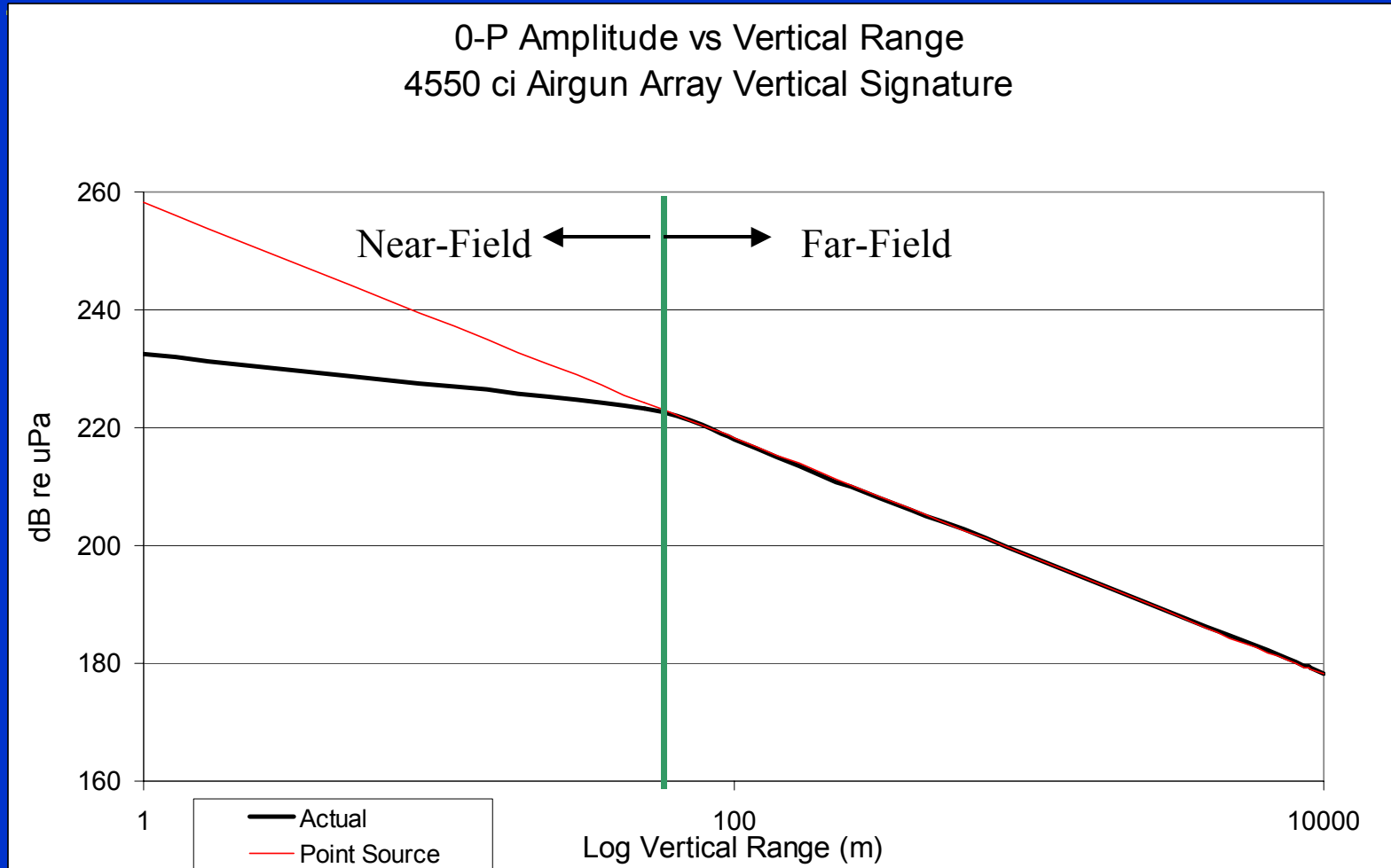
0-P source level = 80 bar-m (258 dB re 1 uPa-m at 3 – 800 Hz)
= 57 bar-m (255 dB re 1 uPa-m at 3 – 128 Hz)

Airgun Array Signatures

The pressure of the quoted source level is never realized at any point in the water column.

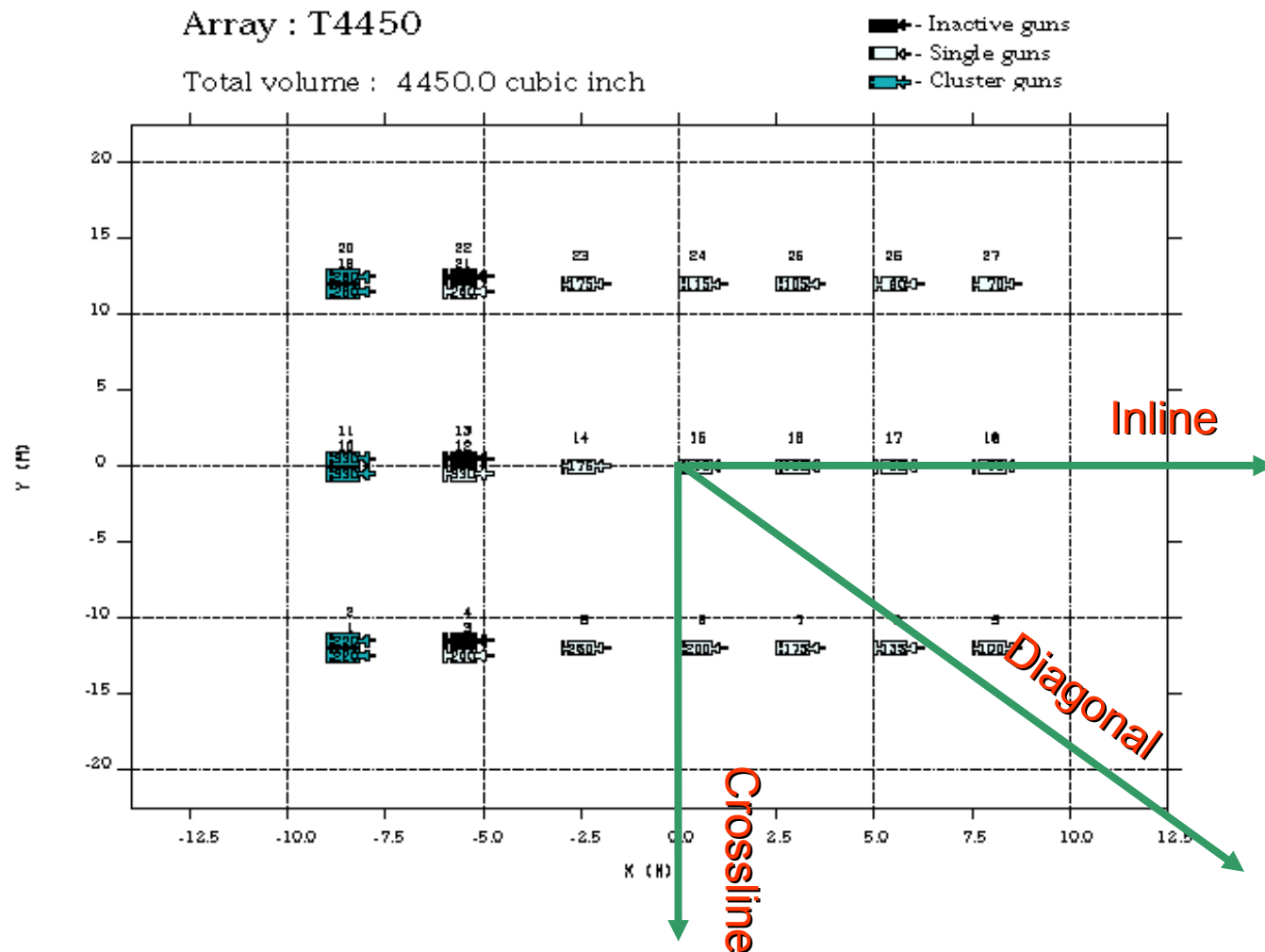
Airgun Arrays – Near vs Far Field

In the far-field, the output of the array decreases inversely with the distance ($1/r$) ..

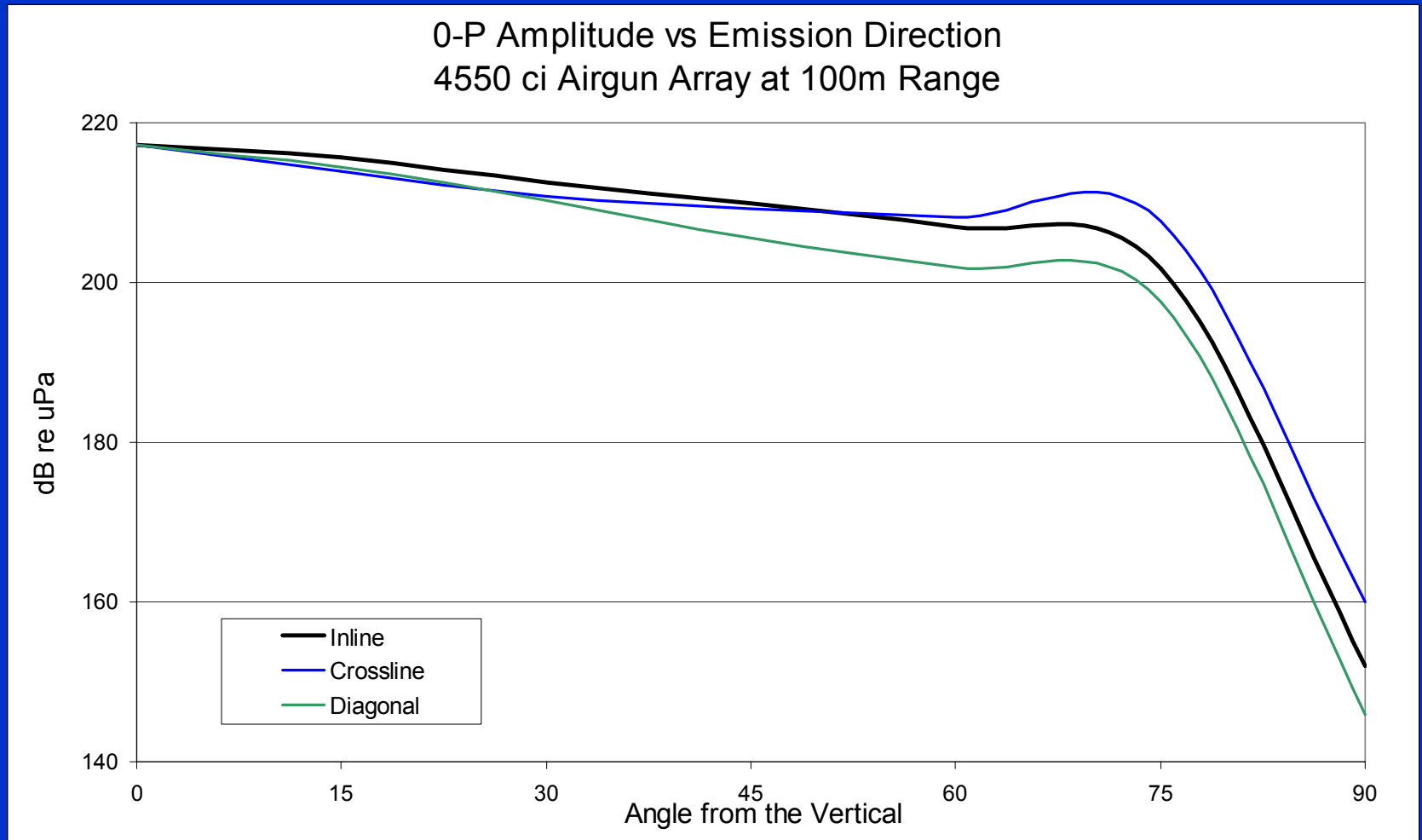


However, the maximum pressure in the water is around 20 dB (i.e $1/10$) less than predicted by the point source assumption.

Airgun Arrays

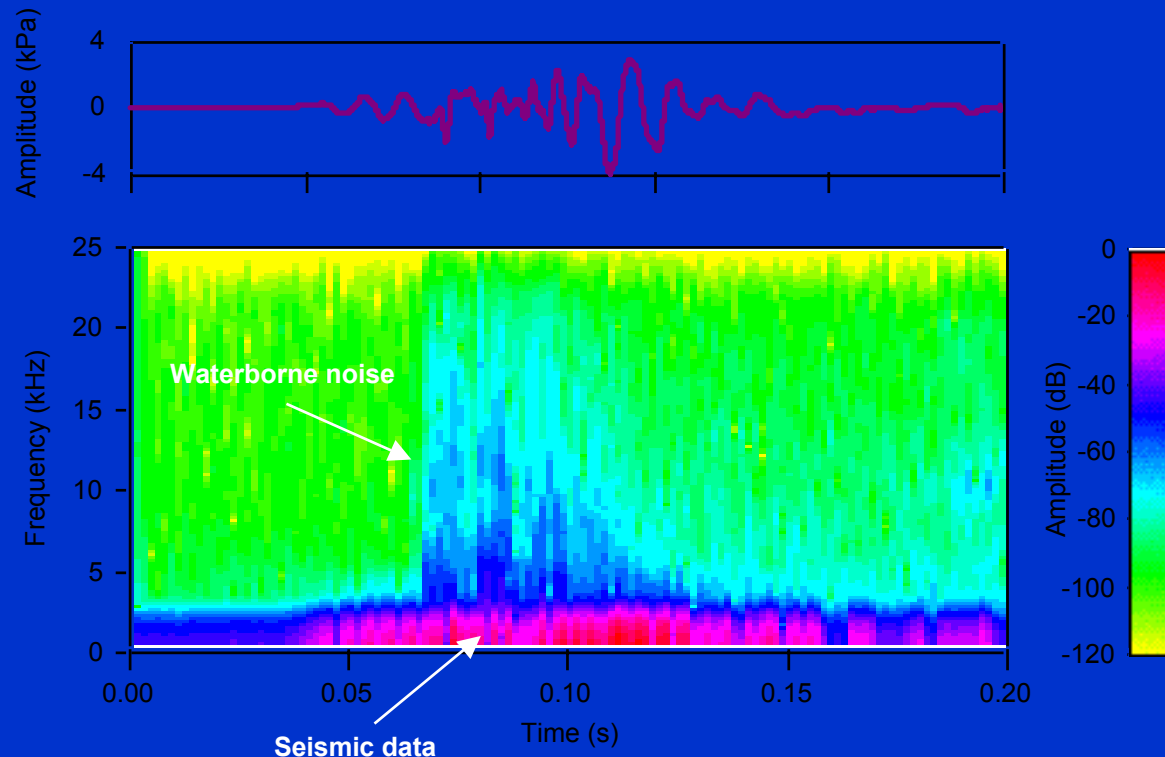


Airgun Array Directivity



High Frequency Emissions from Airgun Arrays

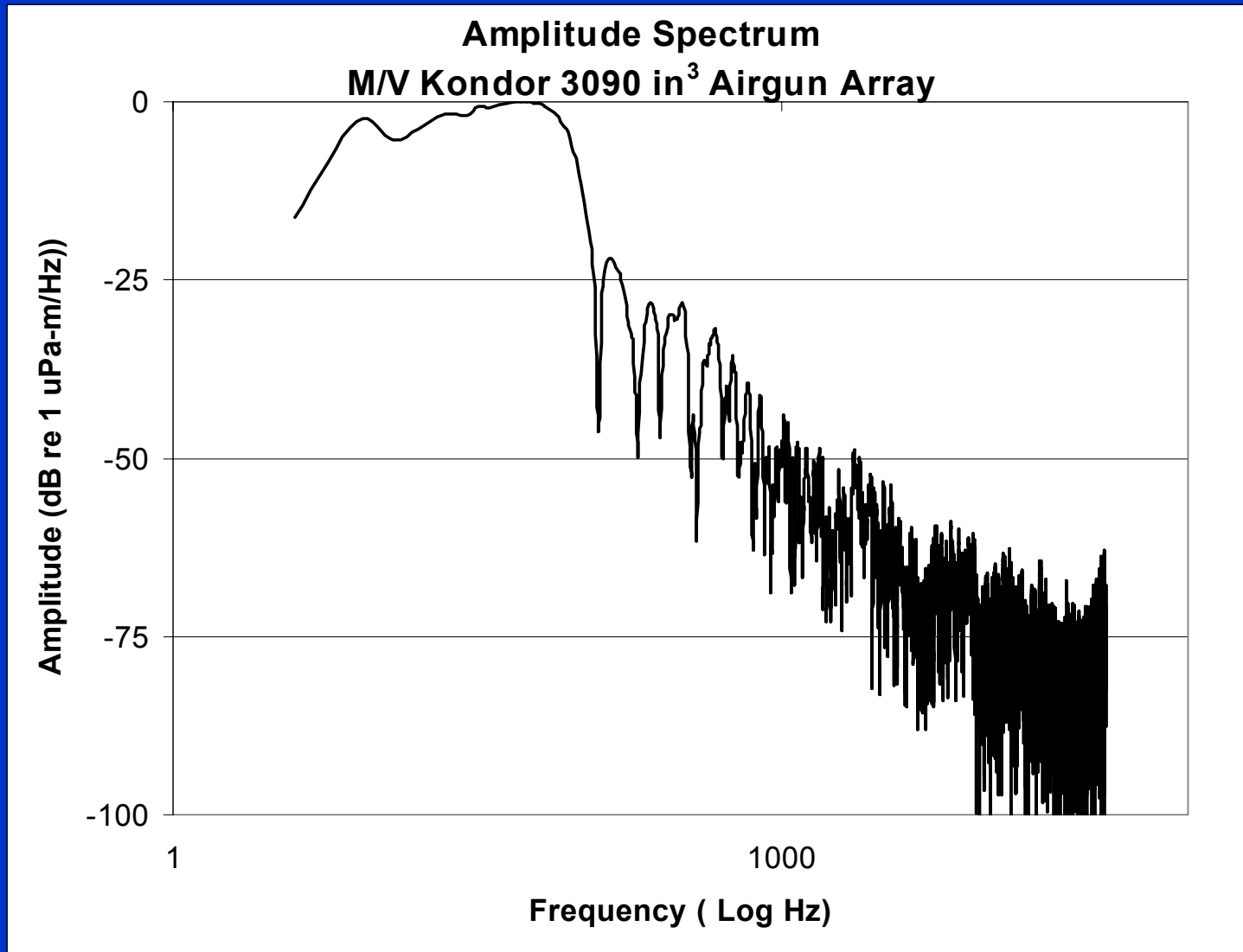
Observations - Acoustic event from seismic exploration
Gabor transform (time - frequency analysis) of first arrival



Survey type: standard North Sea
Water-depth: 40 m
Observation distance: 500 m

Slide Courtesy of Peter Van der Sman, SIEP

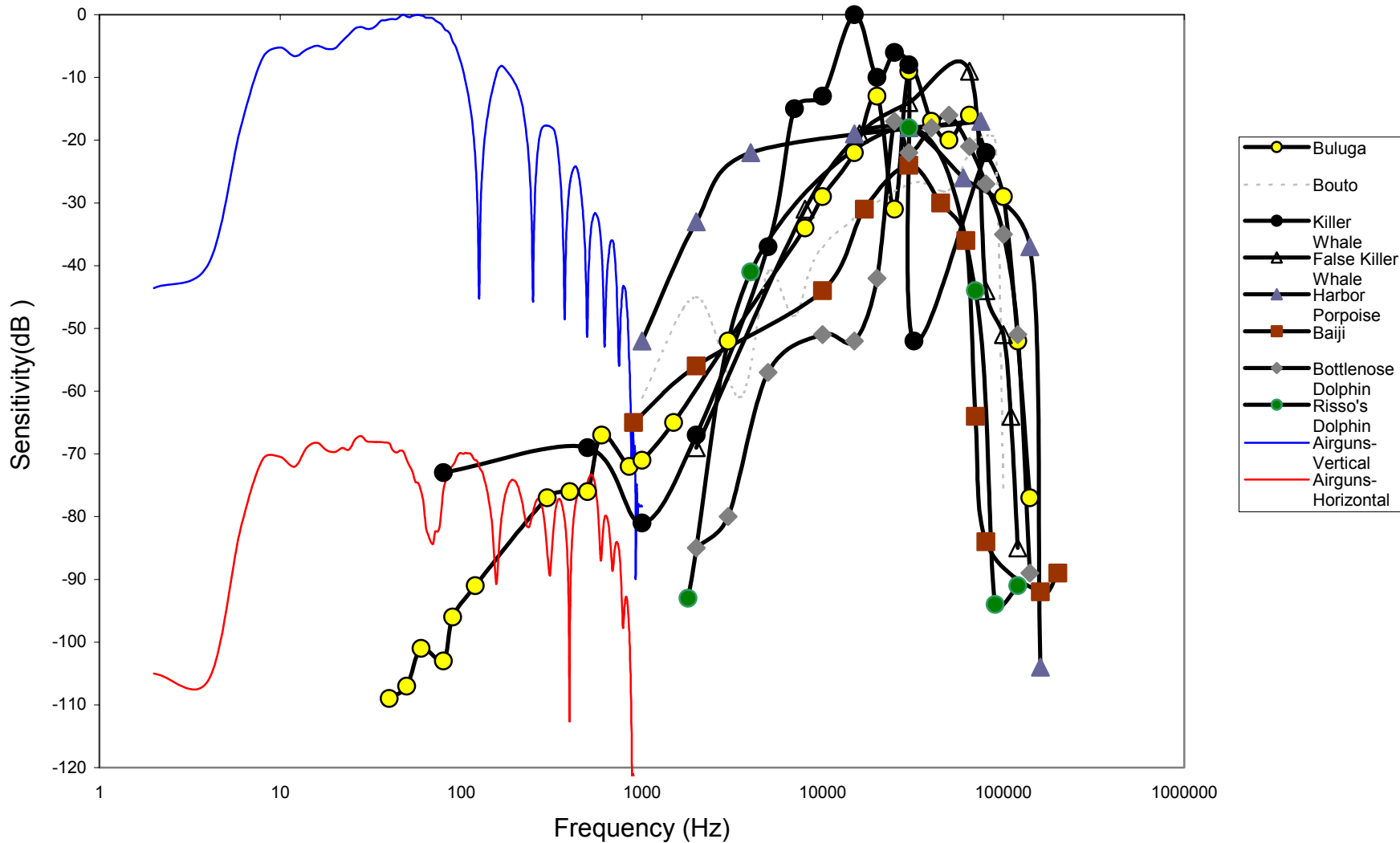
Airgun Array High Frequency Measurement



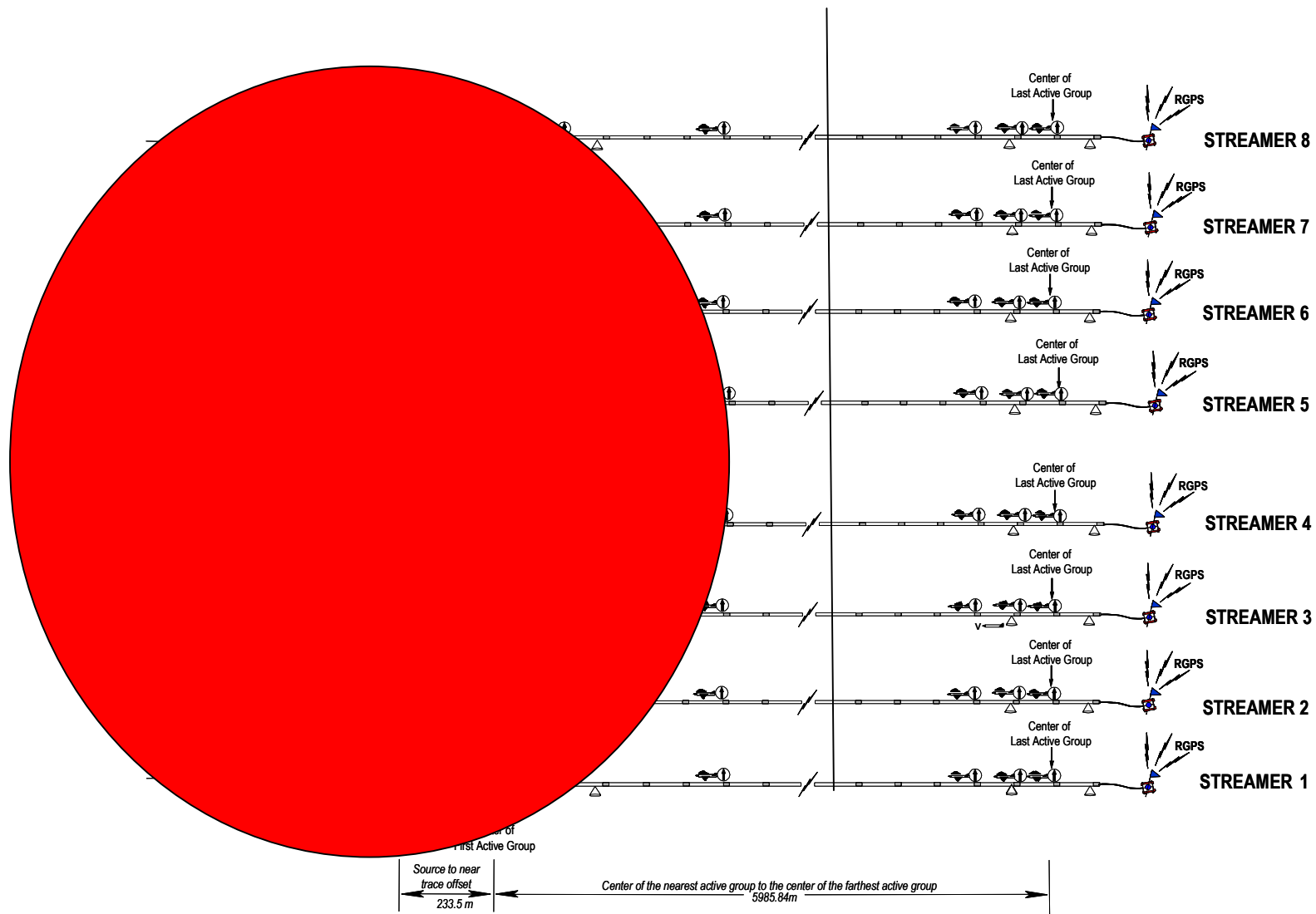
Near vertical airgun array signature measured with a deep moored hydrophone system capable of recording frequencies up to 25 KHz

Comparison of Normalized Sensitivity Spectra for Toothed Whales Relative to Acoustic Output from a Typical Deep Water 3D Airgun Array

Spectral Overlap
Odontocete versus Airgun Array



500m Exclusion Zone



Environmental Stewardship

All geophysical contractors have pledged to conduct business in a manner that respects and preserves the environment in which they operate.

That pledge is especially true with respect to interactions with marine mammals.

